Amendment of Proceedings

(Amendment under the provisions of article 11 of the law [PCT Article 34(2)(b)])

To: Director-General of the Patent Office

1. Indication of International Application: PCT/JP2004/008312

2. Applicant

Name: JAPAN SCIENCE AND TECHNOLOGY AGENCY

Address: 1-8, Honcho 4-chome, Kawaguchi-shi, Saitama 332-0012 JAPAN

Nationality (name of country) JAPAN

Address (name of country) JAPAN

3. Agent

Name: (10867) patent attorney, Yoshiyuki NISHI

Address: Nishi Patent Office Suite, 211, 26-32, Nakahara 4-chome, Isogo-ku, Yokohama-shi, Kanagawa 235-0036 JAPAN

4. Object of amendment Specification and claims

5. Contents of amendment

(1) In line 27 on page 4 of the Japanese specification (line 14 on page 9 in the English specification), "(1) ... from the surface of the magnet" is amended to -- (1) ... from the surface of the magnet having a rare earth-rich grain boundary layer disposed between main crystals--.

(2) In line 28 on page 4 of the Japanese specification (lines 12 to 16 on page 9 of the English specification), "enriched in element M ... " is amended to -- enriched in element M ... and reaction of the element M with the rare earth-rich phase--.

(3) In line 14 on page 5 of the Japanese specification (line 17 to 18 on page 10 of the English specification), "(4) ... from the surface thereof" is amended to -- (4) ... from

the surface thereof, the magnet having the rare earth-rich grain boundary layer disposed between main crystals--.

(4) In line 19 on page 5 of the Japanese specification (line 22 to 23 on page 10 of the English specification), "enriched in the element M" is amended to -- enriched in the element M by reaction with the rare earth-rich phase--.

(5) In claim 1 on page 20 of the Japanese specification (claim 1 on page 42 of the English specification), " from the surface thereof" is amended to -- from the surface of the magnet having a rare earth-rich grain boundary layer disposed between main crystals--.

(6) In claim 1 on page 20 of the Japanese specification (claim 1 on page 42 of the English specification), "enriched in element M ..." is amended to -- enriched in element M ... and reaction of the element M with the rare earth-rich phase--.

(7) In claim 4 on page 20 of the Japanese specification (claim 4 on page 43 of the English specification), "a magnet supported in a reduced pressure vessel" is amended to -- a magnet supported in a reduced pressure vessel, ... the magnet having a rare earth-rich grain boundary layer disposed between main crystals--.

(8) In claim 4 on page 20 of the Japanese specification (claim 4 on page 43 of the English specification), "enriched in element M ..." is amended to -- enriched in element M by reaction with the rare earth-rich phase--.

6. List of the attached documents

(1) Specification; pages 4, 4/1, 5, and 5/1 (English specification; 9, 9/1, 10, and 10/1)

Claims; page 20 (English specification; pages 42 and 43)

crystal structure of a sintered magnet and the function of an element such as Dy or the like contained in the magnet on the basis of the coercive force mechanism of an Nd-Fe-B rare earth-based magnet, the inventors succeeded in developing a high-performance rare earth-based magnet in which a rare earth metal such as Dy or the like is thinly distributed inside the magnet and thickly distributed on the surface side, thereby effectively utilizing the rare earth metal such as Dy or the like in the magnet.

(1) The present invention relates to a rare earth-iron-boron based magnet including a crystal grain boundary layer which is enriched in element M (M is at least one rare earth element selected from Pr, Dy, Tb, and Ho) by diffusion from the surface of the magnet having a rare earth-rich grain boundary layer disposed between main crystals and reaction of the element M with the rare earth-rich phase, the coercive force H_{cj} and the content of the element M in the whole of the magnet satisfying the following equation:

$$H_{cj} \geq 1 + 0.2 \times M \text{ (wherein } 0.05 \leq M \leq 10)$$

wherein H_{cj} is the coercive force (unit: MA/m), and M is the content of the element M in the whole of the magnet (% by mass).

(2) The present invention also relates to the rare earth-iron-boron based magnet described in (1) in which the residual magnetic flux density Br and the coercive force H_{cj}

satisfy the following equation:

$$Br \geq 1.68 - 0.17 \times H_{cj}$$

wherein Br is the residual magnetic flux density (unit: T)

(3) The present invention also relates to the rare earth-iron-boron based magnet described in (1) or (2), which is produced by powder molding and sintering or by powder molding and hot plastic processing, the magnet including a rare earth-rich grain boundary layer disposed between main crystals.

(4) The present invention further relates to a method for producing the rare earth-iron-boron based magnet described in any one of (1) to (3), the method including physically spraying a vapor or fine particles of element M (M is at least one rare earth element selected from Pr, Dy, Tb, and Ho) or an alloy containing the element M onto the entire surface or a portion of the surface of a magnet supported in a reduced-pressure vessel to deposit a film of the element M, and diffusing and penetrating the element M into the magnet from the surface thereof, the magnet having the rare earth-rich grain boundary layer disposed between main crystals, so that the element M reaches at least a depth corresponding to the radius of the crystal grains exposed at the surface of the magnet, thereby forming a crystal grain boundary layer enriched in the element M by reaction with the rare earth-rich phase.

(5) The present invention further relates to the method for producing the rare each-iron-boron based magnet descried

in (4), in which the crystal grain boundary layer is enriched in the element M so that the concentration of the

CLAIMS

1. A rare earth-iron-boron based magnet comprising a crystal grain boundary layer enriched in element M (M is at least one rare earth element selected from Pr, Dy, Tb, and Ho) by diffusion of the element M from the surface of the magnet having a rare earth-rich grain boundary layer disposed between main crystals and reaction of the element M with the rare earth-rich phase, wherein the coercive force H_{cj} and the content of the element M in the entire of the magnet satisfy the following equation:

$$H_{cj} \geq 1 + 0.2 \times M \text{ (wherein } 0.05 \leq M \leq 10)$$

Wherein H_{cj} is the coercive force (unit: MA/m), and M is the content of the element M in the entire magnet (% by mass).

2. The rare earth-iron-boron based magnet according to claim 1, wherein the residual magnetic flux density Br and the coercive force H_{cj} satisfy the following equation:

$$Br \geq 1.68 - 0.17 \times H_{cj}$$

wherein Br is the residual magnetic flux density (unit: T).

3. The rare earth-iron-boron based magnet according to claim 1 or 2, wherein the magnet is produced by powder molding and sintering or by powder molding and hot plastic processing, the grain boundary layer rich in the rare earth element is disposed between main crystals.

4. A method for producing a rare earth-iron-boron based magnet according to any one of claims 1 to 3, the method

comprising physically spraying a steam of fine particles of element M (M is at least one rare earth element selected from Pr, Dy, Tb, and Ho) or an alloy containing the element M onto the entire surface or a portion of the surface of a magnet supported in a reduced pressure vessel to deposit a film of the element M, and diffusing and penetrating the element M into the magnet from the surface thereof, the magnet having the rare earth-rich grain boundary layer disposed between main crystals, so that the element M reaches at least a depth corresponding to the radius of the crystal grains exposed on the outermost surface of the magnet, thereby forming a crystal grain boundary layer enriched in the element M by reaction with the rare earth-rich phase.

5. The method for producing a rare each-iron-boron based magnet according to claim 4, wherein the crystal grain boundary layer is enriched in the element M so that the concentration of the element M toward the surface side of the magnet.